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THE OCCURRENCE OF THE GENUS TINGIA IN TEXAS

BY

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The genus tingia is one of the unusual late Paleozoic plant-concepts which was formerly referred to the cycads, but is now considered as being a pteridophytic alliance belonging to the Noeggerathiales. Hitherto the genus Tingia has been found only in China and Korea.

In the course of the past four years the Department of Vertebrate Paleontology of the Museum of Comparative Zoölogy of Harvard University has sent expeditions to Texas and New Mexico in quest of Permocarboniferous vertebrates. During field work, representative collections of fossil plants were gathered in more than thirty localities. Among these collections, transmitted to the Botanical Museum for study, is a remarkable florule from Brazos River, Baylor County, Texas, which contains rather lush plants such as are believed to have lived in more or less moist situations. Prominent among these plants is *Tingia*, which is represented by two new species.

Tingia was described by Halle in 1925[1], but in 1927[2] he published an emended description. The emended description is as follows:

Tingia Halle Paleontologica Sinica ser. A. vol. 2. p. 231, 1927.

"Dorsiventral, frond-like, anisophyllous shoots with

a thick axis. Leaves arranged in four rows, two on the upper and two on the lower side of the axis. Leaves of the two rows on the upper side large, spread out in one plane and forming a rather open angle with the axis, those of the rows on the lower side smaller, directed forward at narrow angles or parallel to the axis. Leaves on the upper side varying from broadly obcuneate-obovate to oblong or linear, with entire lateral margins but more or less deeply lobed at the apex. Leaves of the lower side of more or less similar shape but often narrower or more deeply dissected. Several veins entering each leaf, dichotomizing mostly in the lower part of the leaf, all branches continuing to the apex."

Halle described *Tingia* as bearing four rows of leaflets, two of which may be called normal. The additional rows are composed of smaller leaflets, which are partially hidden by the normal ones. The result is an apparently once-pinnatifid frond. In other words, this structure is an axis bearing true leaves, not a leaf-rhachis. Halle compared this condition to the plagiotropic shoots of *Selaginella* and *Lycopodium*, but Nemejc[3] noted that it is very probable that their growth was limited as for instance in the plagiotropic shoots of the Taxodiae (p. 112).

Halle refrained from referring *Tingia* to the cycads, although its closest relative, *Plagiozamites*, was long considered to be the foliage of some cycadeoid. More recently Nemejc (loc. cit.) recognized the affinities between these two genera and *Noeggerathia* Stur. He proposed the name Noeggerathiales to include all three. In his opinion, this "order" is coördinate with Psilophytales, Psilotales, Lycopodiales, Cladoxylales, Articulatales [Equisetales and Sphenophyllales], and Filicales. The group is characterized as follows (loc. cit. p. 114): "Leaves simple (—at least never pinnate—) pseudomacrophyllous, with radiating and dichotomously dividing nervation.

Axis non-articulated. Sporangia with a tendency to serial and collateral arrangement, sitting on the adaxial side of the sporophylls. Sporophylls composing cone-like fructifications."

In a later paper[4], Nemejc described the typical heterosporous pteridophytic spores of *Noeggerathia foliosa* Sternberg.

Modern plant morphologists recognize three phyletic lines among the vascular plants: Lycopsida, Sphenopsida, and Pteropsida, which presumably trace their common origin to the Devonian Psilophytales or Psilopsida. Jeffrey[5] more than thirty years ago proposed two groups, Lycopsida and Pteropsida. The Lycopsida are microphyllous with adaxial sporangia and the Pteropsida are megaphyllous with abaxial sporangia. Scott[6] distinguished two groups of microphyllous plants, the Lycopsida and Sphenopsida. The Lycopsida have spirally arranged leaves and non-articulated axes, while the Sphenopsida have articulated axes and whorled leaves. The Sphenopsida include chiefly, the Equisetales, the Calamitales, and the Sphenophyllales.

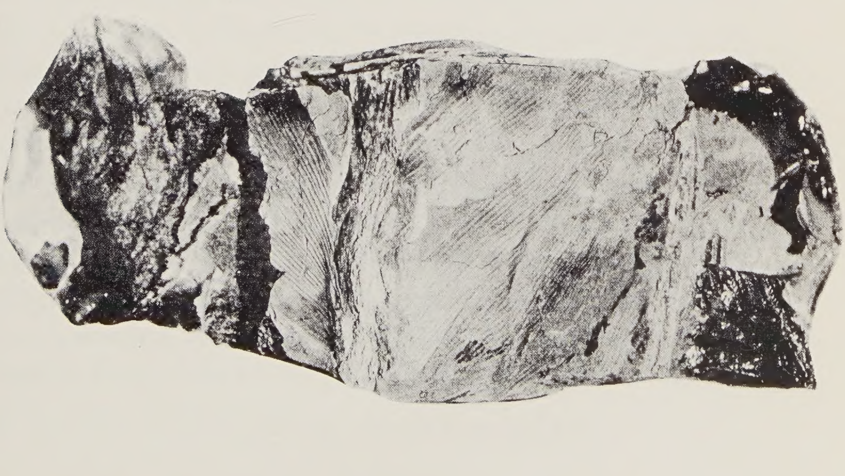
Fructifications of three species of *Noeggerathia* and one attributed to *Tingia* (*Tingiostrobus tetralocularis* Kon'no) have been described.

Lady Isabel Browne has considered this problem from its broader point of view. She concluded that these fructifications belonging to the Noeggerathiales find their closest affinity with the Sphenophyllales. Kon'no[8] considered that they bear closer relationship to the Lycopodiaceae, while Nemejc insisted that they are quite distinct. Lady Browne compared the sporangia of the Noeggerathiales with those of *Sphenophyllum dawsoni* Williamson. In short, she regarded the Noeggerathiales as having simple pseudo-macrophyllous leaves, non-articulated axes, phyllotaxy non-verticillate, and the fructi-

EXPLANATION OF THE ILLUSTRATION

TINGIA TAENIATA *Darrah sp. nov.* Figure at top. The specimen shows the upper part of the axis bearing anisophyllous leaves. Four fifths natural size. Figure at bottom. The specimen shows the stout axis and several linear leaves. The mode of departure of the leaves can be observed on the leaf on the lower left side of the axis. Natural size.

Heliotype reproduction of photographs of the type specimens, numbers 19720 and 19722.



fication sphenophylloid. As a logical conclusion, she suggested that the Pteropsida should include the Cladoxylales and Filicales, the Lycopsida should include the Lycopodiales and perhaps also the Psilotales and Psilophytales, and the Sphenopsida should include the Articulatales and the Noeggerathiales.

If the Articulatales are joined with the Noeggerathiales in the Sphenopsida and the group contains non-articulated forms with non-verticillated phyllotaxy, then it seems to me that the Sphenopsida cannot be separated from the Lycopsida, and that Jeffrey's two groups are natural and inclusive enough to embrace all of the smaller groups excepting the Devonian Psilopsida, which have undifferentiated, leafless, rootless, dichotomized axes with terminal sporangia.

I was unable to interpret the American specimens of *Tingia* until the method of preparation described by Halle was applied to our specimens. He noted that "the rock always splits along the plane of the large leaves, one counterpart showing the impression on the upper side, the other that of the lower. . . . if the matrix bearing the impressions of the lower side of the large leaves, and of the axis, is removed, the smaller leaves are always found to be present." We were disposed to risk only two specimens of the nine available, because of the very fragile nature of the matrix. On both of these specimens the typical arrangement of the small leaves can be observed.

Halle has described three species: *Tingia carbonica* (Schenk) Halle, *T. crassinervis* Halle, and *T. partita* Halle. Kon'no has described two others from Korea, *Tingia hamaguchii* Kon'no and *T. elegans* Kon'no. He also recorded the occurrence of *T. partita* and *T. cf. carbonica* from Korea. All of the species are found in rocks of Lower Permian age.

Tingia taeniata *Darrah sp. nov.* 2 figures.

Shoot dorsiventral, frond-like, anisophyllous, with stout axis. Leaves arranged in four rows, two on the lower side of the axis and two on the upper side, the latter forming an angle of 30–45° with the axis. Leaves of the rows on the upper side large and spreading in one plane, gradually diminishing in size terminad. Apex of the leaves slightly dissected and lobed. Veins broad and conspicuous, bifurcating several times near the base of the leaf and running in parallel directions to the apex of the leaf.

The specific name indicates the linear, ribbon-like shape of the leaves.

This species is related to *Tingia carbonica* (Schenk) Halle, but it differs in its much stouter axis, coarser veins, and its more linear leaves. It may be compared with Halle's plate 62, figure 5 (Schenk's type of *Pterophyllum carbonicum*) and plate 63, figures 4 and 5. *Tingia taeniata* resembles *T. crassinervis* Halle in having a very stout axis and coarse veins, but differs in having more numerous veins and in the linear shape of the leaves.

Texas: Baylor County, 15 miles southeast of Seymour, on the Emily Irish land on the South side of Salt Fork of the Brazos River. Upper part of the Belle Plains Formation; Wichita Group; Permian, in my opinion. *Mrs. J. F. Kemp 19722, 19720* (Cotypes in Paleobotanical Collection, Botanical Museum of Harvard University).

Tingia kempiae *Darrah sp. nov.* 2 figures.

Shoot dorsiventral, frond-like, anisophyllous, with a very thick axis and four rows of leaves. Leaves of the two rows of the upper surface spread in one plane and forming an angle of 60–80° with the axis. Leaves with a broad base, oblong-oblanceolate, three to four times as long as the greatest width. Veins numerous (more than

ten), bifurcating several times near the base, and passing out into the leaf in parallel paths.

No details concerning the leaves of the two lower rows are known except their departure from the axis, which is similar to the departure of the leaves of the upper rows.

The species is named for Mrs. J. F. Kemp, in recognition of her generosity and helpful interest in the paleontology of the Texas Permocarboniferous.

TEXAS: Baylor County, 15 miles southeast of Seymour, on the Emily Irish land on the south side of Salt Fork of the Brazos River. Upper part of the Belle Plains Formation; Wichita Group; Permian, in my opinion. *Mrs. J. F. Kemp 19721, 19723* (COTYPES in Paleobotanical Collection, Botanical Museum of Harvard University).

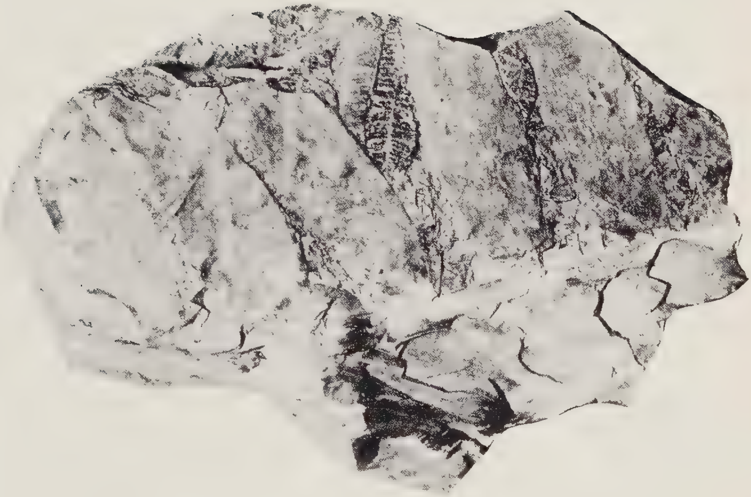
This species resembles *Tingia crassinervis* Halle, but differs in having broader leaves, more numerous veins, and a wider angle of departure. The figured specimens may be compared with Halle's plate 61, figures 1 and 3.

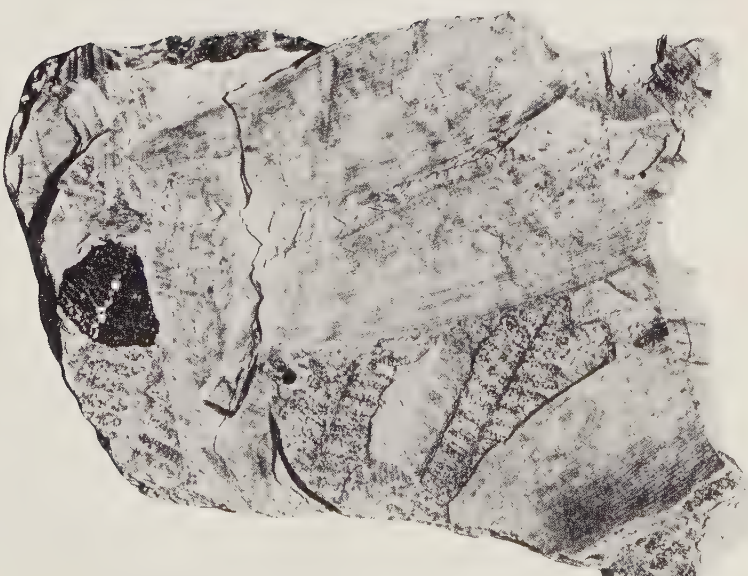
It is noteworthy that both of the American species bear relationship to *Tingia crassinervis* which occurs in the Upper Shihhotse Series of Shansi Province, China. *Tingia carbonica* occurs in the Lower Shihhotse Series of Shansi, and the two species are not found together. Halle concluded that at least the Upper Shihhotse Series belonged to the Lower Permian, and that the Lower Shihhotse probably belonged also within the Lower Permian. Halle[9] recently reported the discovery of *Tingia hamaguchii*, *Tingia carbonica* and *Tingia elegans* from the Nanshan Region (Kansu) of China, in rocks of Lower Permian age. The three species do not occur together, but appear in sequence in a thickness of 1200 meters.

The two species of *Tingia* from Texas occur in an interesting association composed chiefly of the following: *Odontopteris subcrenulata* (Rost.) Zeiller, *Pecopteris*

EXPLANATION OF THE ILLUSTRATION

TINGIA KEMPIAE *Darrah sp. nov.* Figure at top shows the stout axis and five leaves; points of attachment not preserved. One half natural size. Figure at bottom. The specimen shows three leaves with venation preserved. Four fifths natural size. Heliotype reproduction of photographs of the type specimens, numbers 19723 and 19721.





unita Brongniart, *Pecopteris hemitelioides* Brongniart, *Pecopteris candolleana* Brongniart, *Pecopteris arborescens* Schlotheim, *Taeniopteris sp.*, and *Walchia (Ernestia) sp.* The most significant form present is *Callipteris conferta* Goeppert. This last named species is recorded on the basis of two fine specimens.

The plant association in which *Tingia* occurs is in some particulars different from the so-called Permian flora. In common parlance, the Lower Permian flora is the "Red-bed" flora which presumably grew in an arid or semi-arid region. Although both *Walchia* and *Callipteris* are present, the abundant plants are ferns of the *Pecopteris* type.

The correlation of this florule is made simple because of the presence of *Callipteris* which is arbitrarily accepted as the indicator of Permian age. However, the preponderance of Carboniferous fern species warns of difficulty in drawing too fine a division. The Permocarboniferous floras are characterized by an admixture of ferns with such newer (i.e. younger) genera as *Walchia*, *Taeniopteris, Tingia, Gigantopteris,* and finally *Callipteris.*

In Asia there occurs a peculiar flora which may be identified by the presence of *Gigantopteris.* Consequently the region in which it occurs has been designated the "Gigantopteris Province", and the flora has been termed the "Gigantopteris Flora". Halle[10] has suggested that these names are inappropriate because the genus occurs for only a short time, the latest phase, in a far more extensive plant succession. For this more inclusive unit, he uses the name "Cathaysia Flora", after Grabau's Cathaysia land mass.

Gigantopteris occurs also in the American Southwest[11], in Texas and Oklahoma. Here again the vertical extent is remarkably limited. *Gigantopteris* in Texas is younger than *Tingia*[12], and it is noteworthy that *Gigan-*

topteris has been found at several localities without *Callipteris.* For example, at Fulda, Texas there occurs a florule with *Gigantopteris* but without *Callipteris*, which I have previously called "a *Callipteris* flora without *Callipteris*"[13]. The Fulda florule is certainly Permian.

Recently Jongmans and Gothan[14] have described a very similar Gigantopteris flora from Sumatra. *Tingia* and *Callipteris* are absent, and the flora is considered to be pre-Permian, that is Stephanian, and closely related to the oldest Shansi beds (Yemenkou Series).

The floras of eastern Asia and northwestern North America[15] have a considerable number of plants in common. The two land masses lie in proximity, and interchange of forms is inevitable, the rate of interchange being determined by climatic factors. In keeping with this logical approach to the problem of the distribution of *Gigantopteris* and *Tingia*, the only former route of interchange or migration was by way of Alaska, the Aleuetian Islands, and Kamchatka. However, according to the Wegener Hypothesis of continental drift, which is one of the widely held concepts in geology, the problem is not so simple. It must be noted that few American geologists admit the hypothesis of continental drift, although the concept is almost universally accepted among European and southern hemisphere geologists. The thesis, stated in its simplest terms, involves the splitting apart of a single great continental mass into several parts —the existing continents—which gradually drifted to their present positions. The North American continent is assumed to have split off from Europe and is now more remote from its former points of contact than ever before. As the counterpart of this idea, the distance between Asia and western America has been decreasing, so that it is now less than ever before.[16]

The Belle Plains formation, in which *Tingia* occurs

in Texas, is in the upper part of Wichita Group. Romer[17] has given a full stratigraphic correlation chart of the Texas section. The Fulda florule is known from several localities, all in the uppermost part of the Belle Plains. This florule contains *Gigantopteris* and extends upwards into the Clyde formation, Clear Fork Group, and possibly higher.[18] These two florules are to be correlated with the Shihhotse Series of Shansi. It is difficult to compare them with the Korean section, but it appears that closest comparison should be made with the Kobōsan series (Jido of Kon'no).

David White was the first to point out the marked similarity between the late Carboniferous and early Permian floras of Asia and southwestern United States. Halle later observed that not only is this true, but also that even in the Appalachian Province there are Asiatic elements.[19] The discovery of *Tingia* in the Lower Permian rocks of Texas is another link in the chain of evidence pointing to the similarity between the contemporaneous Permocarboniferous floras of Asia and North America. The occurrence of *Tingia* and *Gigantopteris*, and similar genera, in these two regions also indicates that the Wegener concept of drifting continents is not necessary to explain this distribution. This phytogeographic problem, like most others, can best be explained on the basis of proximity of land masses and land bridges.

I wish to express my gratitude to Professor A.S. Romer for his helpful suggestions in my work on the Permocarboniferous floras of the Southwest, to Professor Thomas Barbour, Director of the Museum of Comparative Zoölogy, for the donation of the fossil plants gathered on the paleontological expeditions, to Mr. Robert Witter who was in charge of the 1936 field party, and to Mrs. J.F. Kemp for the gift of the specimens of *Tingia* described in this paper.

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INDEX TO ILLUSTRATIONS

INDEX

TO GENERA AND SPECIES

ERRATA

page 22, line 6
for *Zool-* read *Zoöl-*

page 22, lines 19, 21 and 24
for middle-lobe read middle lobe

page 24, lines 3 and 7
for *Zool-* read *Zoöl-*

page 24, line 23
for middle-lobe read middle lobe

page 47, line 15
for or read on

page 59, line 16
delete hyphen after anguste

page 60, line 2
for deep read in diameter

page 61, footnote
for 78-80 read 84-86

page 63, line 33
for 70 read 77

page 67, line 7
for 67 read 73

page 77, line 5
for *kotschoubeyanus* read *Kotschoubeyanus*

page 77, line 9
for *ritterii* read *Ritteri*

page 77, line 10
for *disciformis* DC. read *disciformis* (DC.) Britton & Rose

page 77, line 11
for *denegrii* read *Denegrii*

page 77, line 18
for *tolucanus* read *toluccanus*

page 77, line 20
for *Rhychosia* read *Rhynchosia*

page 82, line 2
for *kotschoubeyanus* read *Kotschoubeyanus*

page 82, line 7
for *ritterii* read *Ritteri*

page 82, line 9
for *denegrii* read *Denegrii*

page 82, line 12
for *disciformis* DC. read *disciformis* (DC.) Britton & Rose

page 82, line 21
for *tolucanus* read *toluccanus*

page 84, line 22
for *rungei* read *Rungei*

page 85, line 1
for *rungei* read *Rungei*

page 85, line 23
for *Sophophora* read *Sophora*

page 86, line 34
for *ritterii* read *Ritteri*

page 86, line 36
for *denegrii* read *Denegrii*

page 90, line 1
for 2.65 mm. read 2.65 cm.

page 113, line 23
for *Tropidia ctenophora* Reichb.f. read *Tropidia ctenophora* Benth. & Hook.f. ex Drake

page 119, line 10
for Dutch read German

page 122, line 28
for *1996* read *1995*

page 131, line 31
for Mem. read Mém.

page 137, line 27
for belong read belongs

page 138, line 6
for *Godeffroyanum* read *Godeffroyanus*

page 138, line 31
for *guamensis* read *guamense*

page 140, line 2
for inverse-conic read conical

page 160, line 17
after Form insert a period

page 174, line 19
for leaf-rhachis read leaf-rachis

Reprinted February 1972.